EXTENDED DORMANCY OF CHAPARRAL SHRUBS DURING SEVERE DROUGHT

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Chaparral shrub species display a diversity of rooting types ranging from shallow fibrous systems to those which are deep penetrating (Hellmers *et. al.*, 1955). It might be assumed that these differences result in differential growth periods in response to seasonal changes in the moisture levels in the soil profile. The objective of this study was to establish and quantify this probable relationship. Toward this end a small topographic unit of apparent climatic and edaphic homogeneity was selected that included shrubs of several species representing different rooting types. This area is located in the Mill Creek drainage of the San Bernardino Mountains at an elevation of 3000 ft. Three species were chosen for detailed growth measurements. These were *Heteromeles arbutifolia* (Lindl.) M. Rom. (toyon), a woody shrub with a deep penetrating root system, *Cercocarpus betuloides* Nutt. ex T. & G. (birchleaf cercocarpus), a woody shrub with a shallow, wide spreading root system, and *Salvia apiana* Jeps. (white sage), a subshrub with a shallow, fibrous root system.

At monthly intervals commencing in November, 1960, ten samples were taken from five shrubs of each species in order to record increases in leaf number, area, and weight, as well as increases in terminal shoot length and weight. Procedural details are available elsewhere (Harvey, 1962). These measurements were continued through May, 1961. Soil moisture samples also were taken at the same time intervals at six inch increments from the surface to a depth of 36 inches. On one occasion additional samples were taken to a depth of 120 inches. Precipitation data for the area were obtained from the Mill Creek Ranger Station which is located one mile from the study area at a slightly lower elevation.

From July, 1960, to July, 1961, a total of 5.47 in. of precipitation was recorded at the Mill Creek Ranger Station. All of this rain fell during the period of investigation, but almost half of the total came during November. This is far below normal and may be contrasted with the previous season's total of 15.03 in., and with the 20.33 in. received following the study in 1961–1962.

Soil moisture was at low percentages at depths below six in. during the entire study period. Following the November rain the percentage moisture in the soil at a 12 in. depth was 8.5 per cent. From this amount the percentage steadily decreased to 4.6 per cent in May. The 15 atmosphere tension value for this soil and depth is 5.1 per cent. Thus, during the entire period of study the 12 in. deep soil mosture was at tensions near or greater than 15 atmospheres. Deeper than 12 in. the soil drought was even more pronounced.

The terminal branches of *Salvia apiana* grew only slightly in length, mostly less than an inch. Beginning in January a great number of small leaves were produced; however, none of these expanded appreciably. By May, because of leaf drop in April, leaf area and number were of the same magnitude as in November, and die-back of terminal shoots was quite evident.

Cercocarpus betuloides had no gain in either stem growth or leaf production. Similarly, there was no stem elongation on *Heteromeles arbutifolia*. Although on the latter species several leaves were produced on each terminal branch during December and January, as many were lost during March through May. There was no seasonal production of flowers and fruit on either species.

Terminal stem length measurements only were made on shrubs of *Garrya veatchii* Kell., *Rhamnus californica* Esch., *Prunus ilicifolia* (Nutt.) Walp., and *Quercus dumosa* Nutt. from February to June. No stem growth or flower production occurred on these species during this period.

In summary, shrub growth during the study period as measured by the given criteria was essentially non-existent. The one exception was the slight growth displayed by the shallow, fibrous-rooted *Salvia* plants.

There were no apparent subsequent adverse effects of the prolonged drought on these shrubs. The following year, in the fall of 1962, a cursory examination was made of the three primary shrub species studied. In contrast to the negligible growth of *Salvia* during the drought year, terminal branches of this species averaged 46 inches growth during the 1961–1962 season (flowering branches). Vigorous growth was also evident on *Heteromeles* and *Cercocarpus*. On all three species, many of the terminal buds present during the drought year were dried and had been replaced by lateral bud growth.

Scant evidence is provided to fulfill the original objective of establishing a relationship between the rooting type of chaparral shrubs and the period of growth activity. Only *Salvia apiana*, a shallow, fibrous rooted species, displayed measurable growth. Presumably, this shrub utilized what small amounts of precipitation penetrated the upper levels of the soil profile. A sufficient amount of soil moisture was apparently not available for the growth of deeper rooted species. The drought that occurred during the period of study was of unusual severity. Precipitation for the 1960–1961 season in the San Bernardino region was the lowest recorded in 92 years, and followed two years of subnormal rainfall.

Even in a normal year the chaparral environment may be considered severe for plant growth. The growth period is largely restricted to early spring. In the winter when soil moisture is normally available, low temperatures limit growth. In the summer, although equitable growing temperatures prevail, soil moisture is limiting, and due to a reduction in physiological activity, the plants become dormant. In some seasons, under certain circumstances as described in this report, this dormant state may be of protracted length with conditions at no time being suitable for growth. That these plants can survive such a prolonged period of adverse moisture conditions is a striking indication of their xerophytic adaptiveness.

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CYTOLOGICAL OBSERVATIONS ON SOME GENERA OF THE AGAVACEAE

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Even before Hutchinson (1934) set up the family Agavaceae to include tribes of woody xerophytes from both the Liliaceae and the Amaryllidaceae, McKelvey and Sax (1933), Whitaker (1934), and Satô (1935) pointed out that *Yucca* and *Agave*, together with certain of their allies, must be related because they all have a basic karyotype of 5 long and 25 short chromosomes. This karyotype is too unusual to have been developed along two different evolutionary lines.

Since the new family has been constituted there have been numerous comparative studies of the genera within the family evaluating the evidence for and against the erection of the family (Moran, 1949; Wunderlich, 1950; Cave, 1953). According to many botanists today there is strong evidence for a close relationship of *Yucca* and *Agave*, but their agreement with Hutchinson to place these genera with others such as *Cordyline*, *Dracaena*, *Sansevieria*, *Phormium*, *Nolina*, *Dasylirion*, and *Doryanthes* is not so strong.

One of the lines of cytological evidence useful in taxonomy is the study of the karyotype. Granick (1944) has summarized the information of that date concerning the chromosome numbers in the Agavaceae. Both *Yucca* and *Agave* appear to have widespread hybridization within each genus, but polyploidy so far has been reported only in the latter. Granick discussed polyploidy within *Agave* and concluded that the karyotypes were of little value in determination of individual species, but that there was a definite correlation between polyploidy and vegetative development. The polyploids appear also to have a wider distribution than the diploids. Her counts were made on root tip materials which offer little information as to the possible hybrid nature of the plant examined, especially in the polyploids.

The comparatively long time needed for most of the Agavaceae to mature is probably one of the reasons more cytotaxonomic work has not been achieved on the family. Recently a number of specimens growing at the University of California Botanical Garden, Berkeley, have flow-